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VERIFICATION OF TRANSLATION

I, the undersigned, Makiko TAKEI of Maruman Building, 11-1, Nishi-shinbashi 1-chome, Minato-ku, Tokyo 105-0003, Japan, hereby certify that to the best of my knowledge and belief the following is a true translation into English made by me of the priority document

Japan 319843/2002 filed on November 1, 2002,
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[DOCUMENT] Specification

[TITLE OF THE INVENTION] TRANSMITTER DEVICE AND TRANSMITTING METHOD USING OFDM AND MC-CDMA

[SCOPE OF CLAIMS]

[CLAIM 1] A transmitter device for communicating with a plurality of receiver devices in a cell through radio channels, the transmitter device comprising:

an OFDM transmission means; and

a MC-CDMA transmission means,

wherein the OFDM transmission means or the MC-CDMA transmission means is adaptively used by each slot assigned to a receiver device depends on the propagation conditions to the receiver device.

[CLAIM 2] The transmitter device as claimed in claim 1, wherein

a modulation scheme and a channel coding rate are dynamically changed depends on the propagation conditions to the receiver device when the OFDM transmission is used; and

a modulation scheme, a channel coding rate and a spreading rate are dynamically changed depends on the propagation conditions to the receiver device when the MC-CDMA transmission means is used.

[CLAIM 3] The transmitter device as claimed in claim 1 or 2, wherein the propagation conditions are a distance from

the receiver device and a ratio of carrier power to interference signal power and noise power.

[CLAIM 4] The transmitter device as claimed in claim 3, wherein the OFDM transmission means is used when the distance from the receiver device is short and the a ratio of carrier power to interference signal power and noise power is high, and the MC-CDMA transmission means is used when the distance from the receiver device is long or the ratio of carrier power to interference signal power and noise power is low.

[CLAIM 5] The transmitter device as claimed in claim 3 or 4, wherein the propagation conditions further include a delay spread and a maximum Doppler frequency.

[CLAIM 6] The transmitter device as claimed in one of the claims 1 to 5, wherein the transmitter device further comprises a transmit power control means for controlling a transmit power by slot assigned to the receiver device.

[CLAIM 7] A system including at least two transmitter devices as claimed in one of claims 1 to 6, wherein the two transmitter devices simultaneously transmit the same data to a receiver device sited in an area, where cells of two transmitter devices is adjoining, for a site diversity.

[CLAIM 8] The system as claimed in claim 7, wherein the receiver device, when received the signal of the MC-CDMA, uses a minimum mean square error means or a maximum likelihood

detection means for intersymbol interference of the MC-CDMA.

[CLAIM 9] A transmitting method of a transmitter device for communicating with a plurality of receiver devices in a cell through radio channels, the transmitting method comprising the step of:

transmitting signal adaptively by using either an OFDM scheme or a MC-CDMA scheme by slot assigned to a receiver device depends on propagation conditions to the receiver device.

[CLAIM 10] The transmitting method as claimed in claim 9, wherein

a modulation scheme and a channel coding rate are dynamically changed depends on the propagation conditions to the receiver device when the OFDM scheme is used; and

a modulation scheme, a channel coding rate and a spreading rate are dynamically changed depends on the propagation conditions to the receiver device when the MC-CDMA scheme is used.

[CLAIM 11] The transmitting method as claimed in claim 9 or 10, wherein the propagation conditions are a distance from the receiver device and a ratio of carrier power to interference signal power and noise power.

[CLAIM 12] The transmitting method as claimed in claim 11, wherein the OFDM scheme is used when the distance from the receiver is short and a ratio of carrier power to interference

signal power and noise power is high, and the MC-CDMA scheme is used when the distance from the receiver is long or the ratio of carrier power to interference signal power and noise power is low.

[CLAIM 13] The transmitting method as claimed in claim 11 or 12, wherein the propagation conditions further includes a delay spread and a maximum Doppler frequency.

[CLAIM 14] The transmitting method as claimed in one of the claims 9 to 13, wherein the method further comprises a step of controlling a transmit power by slot assigned to the receiver device.

[DETAILED EXPLANATION OF THE INVENTION]

[0001]

[TECHNICAL FIELD OF THE INVENTION]

The present invention relates to a transmitter device, a system and a transmitting method for a mobile communication.

[0002]

[PRIOR ART]

Commercial service of IMT-2000 (International Mobile Telecommunications-2000) using CDMA2000 (Code Division Multiple Access-2000) radio communication standard has been provided. The IMT-2000 can achieve a transmission speed of 144kbps during movement and 2Mbps during rest.

[0003]

In the future, higher speed will be requested for the mobile communication system in order to realize a download of high-definition moving picture or massive file in addition to an E-mail or an access for the Internet. A study of the 4th generation mobile communication system, which enables a transmission speed of maximum 20Mbps during movement and 100Mbps during rest, has been started.

[0004]

To achieve high-quality and high-speed transmission in a mobile communication environment, transmission method, which has a strong tolerance against the cause of degrading transmission quality and a high-efficiency of frequency usage, is required. Transmission schemes of an OFDM (orthogonal frequency division multiplexing) and a MC-CDMA (multiple carrier-code division multiple access) that transmits spread symbols using a plurality of sub-carriers satisfy these requirements.

[0005]

In the 4th generation mobile communication system, VSF-OFCDM (Variable Spreading Factor-Orthogonal Frequency and Code Division Multiplexing) scheme, which the two-dimensions (frequency and time) spreading is applied, has been proposed in order to achieve a high-speed packet transmission, while keeping a tolerance against intersymbol interference (See Non

patent document 1). The VSF-OFCDM scheme spreads symbols in two-dimensions of frequency and time and controls radio parameters (a spreading rate in frequency and time domain, modulation scheme, a channel coding rate, the number of code multiplex) in adaptation in response to a propagation conditions.

[0006]

[Non patent document 1]

MAEDA, ARATA, ABETA and SAWAHASHI, "VSF-OFDM using 2-dimensional spreading and its characteristic", RCS2002-05, pp. 59-64

[0007]

[PROBLEM TO BE SOLVED BY THE INVENTION]

However, in a cellular system using wide band signal, the same frequency is repeatedly used to extend the cell.

[0008]

The OFDM scheme has difficulty in transmit high-capacity data through in a low CINR (Carrier to Interference Noise Ratio) area where interference may occur by the same channels in other cell.

[0009]

On the other hand, the MC-CDMA scheme has a problem of a lower transmission speed than that of the OFDM, because the MC-CDMA scheme simultaneously transmits the same-copied

signal through some sub-carriers, whereas the OFDM scheme transmits different signals through sub-carriers. A high-speed transmission scheme using code multiplexing is proposed, but this high-speed transmission scheme has a problem that a code orthogonal performance deteriorates under a multi-pass environment.

[0010]

The VSF-OFCDM scheme can realize broadband packet transmission in cellular environment, but it requires complex hardware structure in order to perform both a frequency spreading and a time spreading. Furthermore, it is very difficult to control the frequency spreading and the time spreading independently for each user by means of the hardware.

[0011]

It is therefore an object of the present invention to provide a transmitter device, a system and a transmitting method for a mobile communication by using OFDM and MC-CDMA schemes in order to solve the problems in each scheme mentioned above.

[0012]

[MEANS TO SOLVE THE PROBLEM]

According to the present invention, a transmitter device for communicating with a plurality of receiver devices in cell through radio channel, the transmitter device includes an OFDM

transmission unit and a MC-CDMA transmission unit, and the OFDM transmission unit or the MC-CDMA transmission unit is adaptively used by slot assigned to a receiver device depends on propagation conditions to the receiver device.

[0013]

According to another embodiment of the transmitter device of the present invention, it is preferred that a modulation scheme and a channel coding rate are dynamically changed depends on the propagation conditions to the receiver device when the OFDM transmission unit is used, and a modulation scheme, a channel coding rate and a spreading rate are dynamically changed depends on the propagation conditions to the receiver device when the MC-CDMA transmission unit is used.

[0014]

According to another embodiment of the transmitter device of the present invention, it is also preferred that the propagation conditions are a distance from the receiver device, and a ratio of carrier power to interference signal power and noise power.

[0015]

According to another embodiment of the transmitter device of the present invention, it is further preferred that the OFDM transmission unit is used when the distance from the receiver device is short and the a ratio of carrier power to

interference signal power and noise power is high, and the MC-CDMA transmission unit is used when the distance from the receiver device is long or the ratio of carrier power to interference signal power and noise power is low.

[0016]

According to another embodiment of the transmitter device of the present invention, it is still preferred that the propagation conditions further include a delay spread and a maximum Doppler frequency.

[0017]

According to another embodiment of the transmitter device of the present invention, it is preferred that the transmitter device further includes a transmit power control unit for controlling a transmit power by slot assigned to the receiver device.

[0018]

According to a transmitting system of the present invention, at least two transmitter devices mentioned above are included, and two transmitter devices simultaneously transmit the same data to a receiver device sited in an area, where cells of two transmitter devices is adjoining, for a site diversity.

[0019]

According to another embodiment of the transmitting

system of the present invention, it is preferred that the receiver device, when received the signal of the MC-CDMA, uses a minimum mean square error means or a maximum likelihood detection means for intersymbol interference of the MC-CDMA.

[0020]

According to a transmitting method of the present invention, the transmitting method includes the step of transmitting signal adaptively by using either an OFDM scheme or a MC-CDMA scheme by slot assigned to a receiver device depends on propagation conditions to the receiver device.

[0021]

According to another embodiment of the method of the present invention, it is preferred that a modulation scheme and a channel coding rate are dynamically changed depends on the propagation conditions to the receiver device when the OFDM scheme is used, and a modulation scheme, a channel coding rate and a spreading rate are dynamically changed depends on the propagation conditions to the receiver device when the MC-CDMA scheme is used.

[0022]

According to another embodiment of the method of the present invention, it is also preferred that the propagation conditions are a distance from the receiver device and a ratio of carrier power to interference signal power and noise power.

[0023]

According to still another embodiment of the method of the present invention, it is further preferred that the OFDM scheme is used when the distance from the receiver is short and the ratio of carrier power to interference signal power and noise power is high, and the MC-CDMA scheme is used when the distance from the receiver is long or the ratio of carrier power to interference signal power and noise power is low.

[0024]

According to still another embodiment of the method of the present invention, it is still further preferred that the propagation conditions further includes a delay spread and a maximum Doppler frequency.

[0025]

According to still another embodiment of the method of the present invention, it is also preferred that the same frequency is used for all cells, and the transmitter device further includes a transmit power control unit for controlling a transmit power depends on a receiver device in order to reduce the interference applied to other cells.

[0026]

[PREFERRED EMBODIMENT OF THE INVENTION]

The preferred embodiment of the invention is explained with drawings.

[0027]

Fig. 1 illustrates a cell configuration according to the present invention.

[0028]

The present invention realize a radio communication system with a high-speed and high-quality broadband radio access by selecting an OFDM scheme, which enables high-speed transmission, or a MC-CDMA scheme, which has a high tolerance against interference signals, depends on propagation conditions. The OFDM scheme is used in an area where a distance from a base station is short and where a CINR is high. On the one hand, the MC-CDMA scheme is used in an area where a distance from the base station is long or where the CINR is low. In the multiplexing, the OFDM uses a TDM (Time Division Multiplexing) scheme, the MC-CDMA uses a CDM (Code Division Multiplexing) or TDM scheme, and the OFDM and MC-CDMA scheme are changed in time base.

[0029]

According to the OFDM scheme, it is possible to transmit data at high-speed and high-capacity. However, in a low CINR area, the transmission quality decrease due to the interference from other cells, and it is difficult to transmit data at high-capacity. In such the low CINR area, it is possible to keep the transmission quality by using the MC-CDMA scheme.

Furthermore, in order to obtain the maximum throughput in response to change in the propagation conditions, an adaptive modulation and an adaptive control of the channel coding rate may be performed.

[0030]

As a distance from the base station increases or a CINR decreases, the spreading rate and the adaptive modulation are controlled as follows. Such a controls are applied by each receiver device.

[0031]

(short distance and high CINR)

↓ OFDM 16QAM

↓ QPSK

↓ BPSK

↓ MC-CDMA(PN:4) <-Adaptive Modulation

↓ MC-CDMA(PN:8) <-Adaptive Modulation

↓ MC-CDMA(PN:16) <-Adaptive Modulation

↓ MC-CDMA(PN:32) <-Adaptive Modulation

(long distance or low CINR)

[0032]

In the configuration of Fig. 1, adjacent cells uses the same frequency (one cell repetition) to improve the efficiency of frequency usage, because available bandwidth is restricted in a microwave band. Therefore, the interference may occur

between the cells. Of course, the present invention is applicable to N cells repetition, where N is greater than or equal to 2.

[0033]

In order to reduce the interference applied to other cells as much as possible, it is desired to control a transmitting power in the OFDM scheme at each slot time. On the one hand, the MC-CDMA scheme has high tolerance against the interference signal, since it copies one signal for each receiver device and the copied signal is multiplexed by different spreading codes.

[0034]

For the OFDM and MC-CDMA schemes, a modulation scheme, a channel coding rate and a spreading ratio are dynamically changed based on a distance from the receiver device, a CINR, a delay spreading and/or a maximum Doppler frequency. In addition, in the case of the MC-CDMA scheme, these may be changed based on a position of the receiver device, the number of the receiver devices, the traffic and others.

[0035]

In Fig. 1, site diversity area is indicated around a boundary of the adjacent cell.

[0036]

According to the present invention, site diversity is

performed in adjacent cells and transmission quality can be improved. In particular, in an area near a boundary of the adjacent cell, the spreading ratio in the MC-CDMA is high and the intersymbol interference tends to occur, and thus the transmission quality tends to greatly deteriorate. Therefore, by performing the site diversity, transmission quality can be improved without excessively increasing the spreading ratio of the MC-CDMA scheme by virtue of the site diversity effect.

[0037]

Whether the site diversity is to be performed or not will be determined based on not only the position of the receiver device but also the number of receiver devices, the traffic and others. In this way, by virtue of the site diversity effect, a certain diversity gain can be obtained without excessively increasing the spreading ratio of the MC-CDMA scheme.

[0038]

According to the present invention, since the transmit power and the interference power are reduced by combining the transmit power control in the OFDM scheme and the site diversity effect in the MC-CDMA scheme, the transmission capacity increases.

[0039]

Using of MMSE (Minimum Mean Square Error) method or MLD (Maximum Likelihood Detection) method will solve the

intersymbol interference in MC-CDMA generated in the receiver device.

[0040]

Fig. 2 schematically illustrates a configuration of the transmitter device and the receiver device according to the present invention.

[0041]

The transmitter device 1 has a PN generating unit 11 for generating a PN signal, an encoding interleaving unit 12 for encoding transmit data sequence by performing error-correction and interleaving the encoded data, a mapping unit 13, a pilot signal insertion unit 14, a division multiple transmit unit 15, and a transmit antenna 16.

[0042]

The division multiple transmit unit 15 perform serial-parallel conversion at a serial to parallel converter section 151. In the case of OFDM, the output signals from the serial to parallel converter section 151 are directly input into the inverse fast-Fourier transform (IFFT) section 154. In case of the MC-CDMA scheme, number of the output signals is Nc/SF. Then the each symbol of the outputs signals are copied to SF symbols at the copier section 152. The copied symbols are multiplied by constants $C_{i,j}$ (i=1,2,…,Nc/SF, j=1,2,…,SF) at a spreading section 153. Where Nc shows the

number of sub-carriers, and for all i, SF shows a spreading factor.

[0043]

In case of the OFDM scheme, the output symbol from the serial to parallel converter section 151 is transformed into values at the respective sample points in a time base at the IFFT section 154, and in case of the MC-CDMA scheme, the total Nc symbols multiplied are transformed at the IFFT section 154. The parallel signals are converted into a serial signal at a parallel to serial converter section 155, and a guard interval is added to the serial signal at a guard interval (GI) section 156. The guard interval is used in order to avoid the intersymbol interference by a delay wave.

[0044]

The receiver device 2 has a receive antenna 21, a division multiple receive unit 22 and a decoding de-interleaving unit 23.

[0045]

The division multiple receive unit 22 correlates the preamble signal at a guard interval section 221, and the guard interval is removed. The GI-removed serial signal is converted into parallel signals at a serial to parallel converter section 222. The converted signal is transformed into signals at a fast-Fourier transform (FFT) section 223.

In case of the OFDM scheme, the output signals from the FFT section 223 are directly input into a parallel to serial converter section 226. In case of the MC-CDMA scheme, the output signal respectively is input into an inverse spreading section 224, and is multiplied by constant $C_{i,j}$. Then, a channel estimation result of each sub-carrier obtained from a pilot symbol is output from a channel estimator section 227. A distortion of the propagation path is compensated by using the channel estimation result from the channel estimator section 227 at combiner sections 225, and the signal is inverse-spread on frequency base according to an integration operation of a matching filter.

[0046]

In case of the OFDM scheme, the output signal from the FFT section 223 is converted into a serial signal at the parallel to serial converter section 226, and in case of the MC-CDMA scheme, the inverse-spread signals are converted to a serial signal at the parallel to serial converter section 226.

[0047]

Finally, the serial signal is demodulated at the decoding de-interleaving unit 23, and thus the transmitted signal is reconstituted.

[0048]

Fig. 3 schematically illustrates a frame configuration for slot assignment based on the TDM according to the present invention.

[0049]

As shown in Fig. 3, based on a frame consisted of a plurality of time slots, the radio parameters, for example a modulation scheme, a transmission rate, a spreading rate, is assigned to each time slot dynamically. Thereby, it becomes possible to assign a channel at the optimum according to the number of users, QoS (Quality of Service), the transmission quality and others.

[0050]

Random access in an uplink channel fundamentally transmits the packets based on Slotted ALOHA. For example, MC-DS/CDMA (Multiple Carrier-Direct Sequence/Code Division Multiple Access) scheme or SC-DS/CDMA (Single Carrier-Direct Sequence/Code Division Multiple Access) scheme is applicable to realize the multimedia transmission, such as moving picture and access of the Internet, in mobile communication environment.

[0051]

Many widely different embodiments for the transmitter device, a system and a method according to the present invention may be constructed without departing from the spirit and scope

of the present invention. It should be understood that the present invention is not limited to the specific embodiments described in the specification, except as defined in the appended claims.

[0052]

[ADVANTAGE OF THE INVENTION]

As mentioned above, according to the present invention, the transmission quality and characteristic of a radio link is improved by virtue of the high-speed transmission in the OFDM scheme, and the frequency diversity effect and the site diversity effect in the MC-CDMA scheme. Thus it realizes the high-speed and high-quality broadband radio access compared to the prior art. In particular, the hardware can be relatively simple and the transmission speed becomes over 100 Mbps at the maximum, because the spreading is performed in frequency domain only for a downlink channel from the base station, and it is possible to realize the high-speed radio communication system, which can easily extend the area.

[0053]

Specifically, in an area where a distance from a base station is short and CINR is high, the high-speed transmission is achieved by using the OFDM scheme. On the other hand, in an area where a distance from the base station is long or CINR is low, the transmission quality is improved by using the

MC-CDMA scheme with high spreading factor, which can obtain frequency diversity effect. Furthermore, the intersymbol interference is reduced by applying the site diversity for the receiver device in an area between adjacent cells where the interference occurs by the same channel from other cells.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Fig. 1] Fig. 1 illustrates a cell configuration according to the present invention;

[Fig. 2] Figs. 2 shows a block diagram schematically illustrating a configuration of a transmitter device and a receiver device in a preferred embodiment according to the present invention; and

[Fig. 3] Fig. 3 illustrates a frame configuration for slot assignment based on a TDM according to the present invention.

[EXPLANATION OF THE NUMERALS]

11 PN generating unit

12 encoding interleaving unit

13 mapping unit

14 pilot signal insertion unit

15 division multiple transmit unit

151 serial to parallel (S/P) converter section

152 copier section

153 spreading section

154 inverse fast-Fourier transform section

155 parallel to serial converter section

156 guard interval section

16 transmit antenna

21 receive antenna

22 division multiple receive unit

221 guard interval section

223 fast-Fourier transform section

224 inverse spreading section

225 combiner sections

226 parallel to serial converter section

227 channel estimator section

23 decoding de-interleaving unit

[DOCUMENT] Abstract

[ABSTRACT]

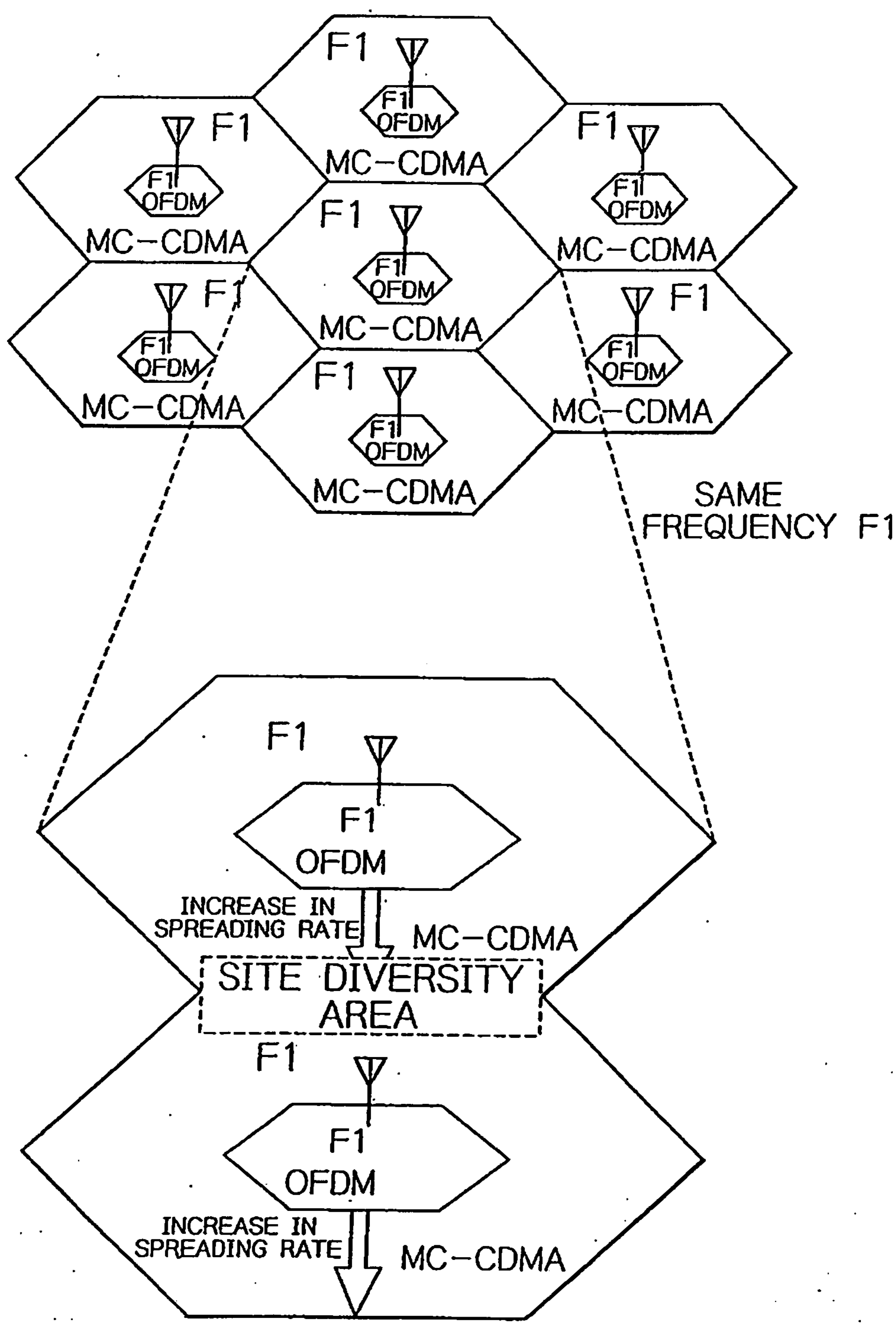
[PROBLEM] It is an object of the present invention to provide a transmitter device, a system and a transmitting method for a mobile communication in order to solve the problems in OFDM and MC-CDMA scheme.

[MEANS TO SOLVE THE PROBLEM] A transmitter device includes an OFDM transmission unit and a MC-CDMA transmission unit, and the OFDM transmission unit or the MC-CDMA transmission unit is used for transmission by slot assigned to a receiver device depends on propagation conditions to the receiver device. A modulation scheme and a channel coding rate are dynamically changed depends on the propagation conditions to the receiver device when the OFDM transmission is used, and a modulation scheme, a channel coding rate and a spreading rate are dynamically changed depends on the propagation conditions to the receiver device when the MC-CDMA transmission means is used. The propagation conditions are a distance from the receiver device and a CINR.

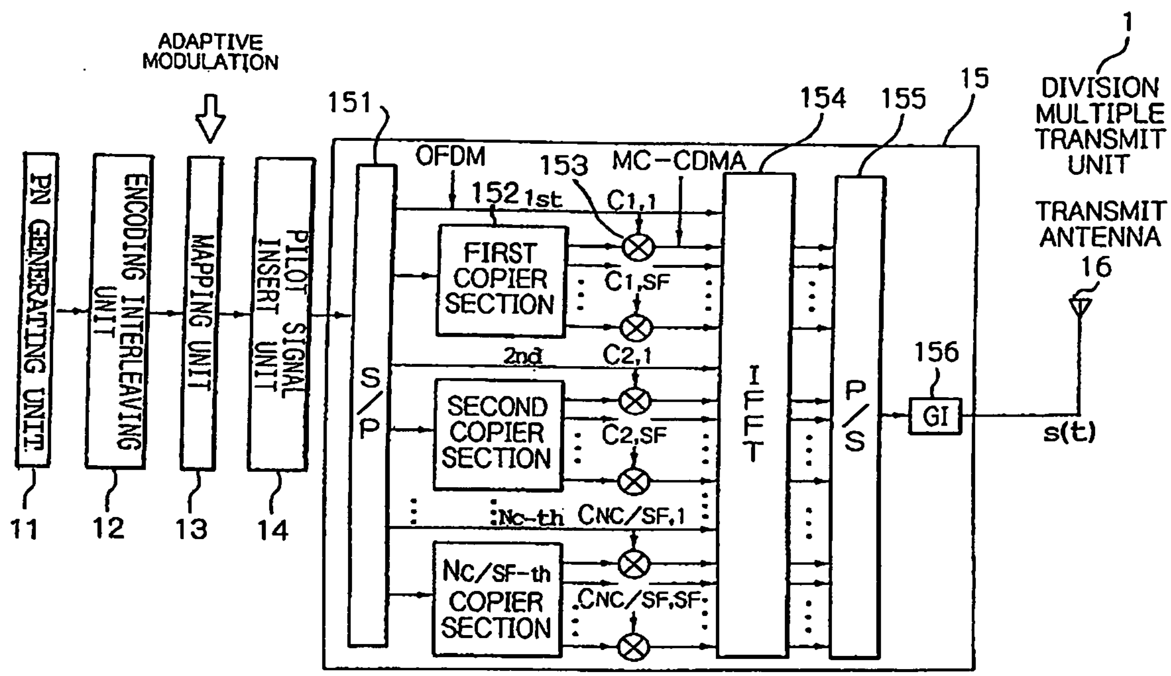
[SELECTED FIGURE] Fig. 1

[DOCUMENT] Drawings

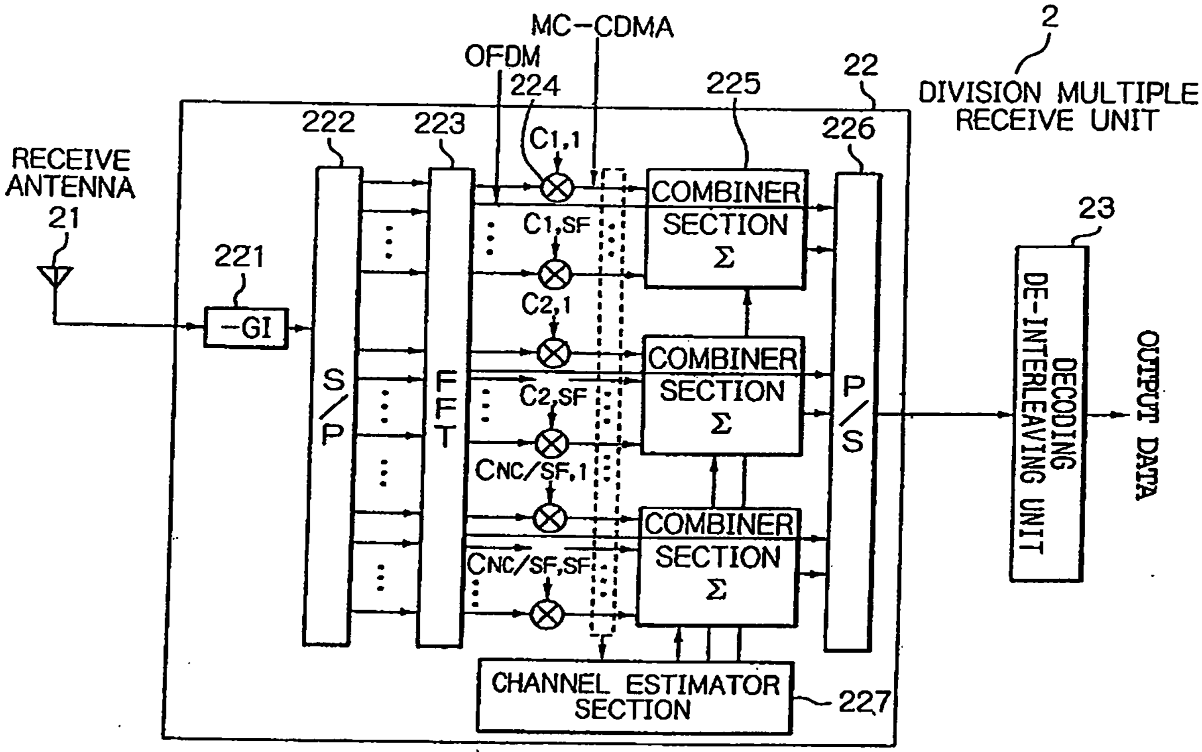
[Fig. 1]



[Fig. 2]

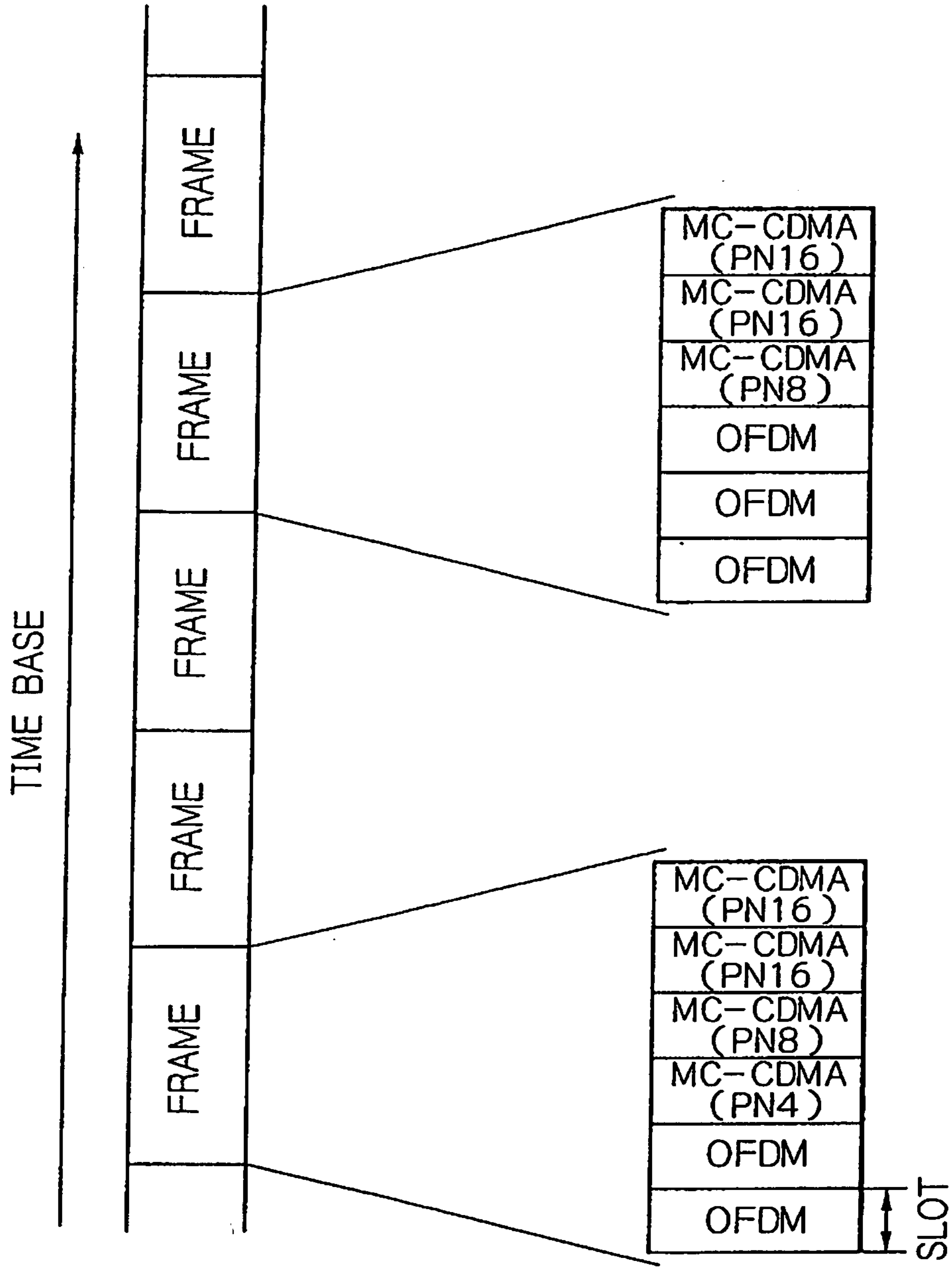


ADAPTIVE MODULATION
PN GENERATING UNIT
ENCODING INTERLEAVING UNIT
MAPPING UNIT
PILOT SIGNAL INSERT UNIT
11
12
13
14
151
OFDM
152
1st
153
C1,1
MC-CDMA
154
155
15
1
DIVISION MULTIPLE TRANSMIT UNIT
TRANSMIT ANTENNA
16
S/P
FIRST COPIER SECTION
C1,SF
2nd
C2,1
SECOND COPIER SECTION
C2,SF
Nc-th
CNC/SF,1
Nc/SF-th COPIER SECTION
CNC/SF,SF
IFFT
P/S
156
GI
s(t)



MC-CDMA
OFDM
224
225
22
2
DIVISION MULTIPLE RECEIVE UNIT
222
223
226
RECEIVE ANTENNA
21
C1,1
C1,SF
C2,1
C2,SF
CNC/SF,1
CNC/SF,SF
221
-GI
S/P
FFT
COMBINER SECTION Σ
COMBINER SECTION Σ
COMBINER SECTION Σ
P/S
23
DECODING DE-INTERLEAVING UNIT
OUTPUT DATA
CHANNEL ESTIMATOR SECTION
227

[Fig. 3]


TIME BASE
FRAME
FRAME
FRAME
FRAME
FRAME
MC-CDMA (PN16)
MC-CDMA (PN16)
MC-CDMA (PN8)
OFDM
OFDM
OFDM
MC-CDMA (PN16)
MC-CDMA (PN16)
MC-CDMA (PN8)
MC-CDMA (PN4)
OFDM
OFDM
SLOT